Observation of coherent e^+e^- pair production with mutual nuclear excitation in $\mathrm{Au}+\mathrm{Au}$ collisions at $\sqrt{s_{NN}} = 200$ GeV

V. Morozov, S.R. Klein, F. Meissner, and the STAR Collaboration

We report the measurement of e^+e^- pair production via coherent $\gamma\gamma$ interaction ($AuAu \to Au^*Au^* + e^+e^-$) in ultra–peripheral heavy ion collisions. The photons couple coherently to the Au ions, as the result the photon flux of a single ion is proportional to Z^2 and the cross–section scales as Z^4 ($\sim 3.8\times 10^6$ for Au). The applicability of QED perturbation theory for the pair production is questionable because the coupling constant of photons to the nucleus is large ($Z\alpha \sim 0.6$ for Au)[1]. The nuclear excitation is believed to occur via an exchange of two or more photons between the ions, which excites the ions into the state of Giant Dipole Resonance (GDR). The GDR decays primarily by the emission of neutrons in the direction of the beam.

We select such events by requiring coincident signals in the East and West forward neutron calorimeters (Minimum Bias Trigger). The e^+e^- pair tracks in the tagged collisions are observed with a STAR Time Projection Chamber (TPC). The TPC has a greater than 90% tracking efficiency for medium energy tracks at mid–rapidity (track momentum $p_\perp^{track} > 65$ MeV and pseudorapidity $|\eta^{track}| < 1.15$). To separate electrons and positrons from other particles we use dE/dx, which allows electron/positron track identification for total track momenta below 125 MeV. These requirements limit the observed e^+e^- pairs to the kinematical range of pair invariant mass 130 MeV $< W_{e^+e^-} <$ 265 MeV, pair rapidity $|Y| < 1.15$ and $cos(\theta^*) < 0.7$, where the θ^* is the angle between the momentum of the photons and electron/positron momentum in the center–of–mass frame.

To study the tracking efficiency, we have developed a Monte Carlo simulation of the e^+e^- pair production with mutual nuclear excitation. The photon fluxes from the Au ions are calculated according to the Weizsäcker–Williams equivalent photon approximation. The routine uses the lowest–order QED approximation for the $\gamma\gamma \to e^+e^-$ annihilation and assumes that the pair production is independent of electromagnetic excitation of the Au ions. Figures 1 and 2 show the pair spectra in invariant pair mass $W_{e^+e^-}$ and total pair transverse momentum $p_\perp^{tot}$. The cross–section drops off rapidly with increasing $W_{e^+e^-}$ and the pair $p_\perp^{tot}$ peaks at ~ 20 MeV, which is a consequence of the coherent coupling of the interacting photons to the Au ions[2].

We have identified 61 e^+e^-ultra–peripheral pairs in the sample of 800,000 events collected with the Minimum Bias trigger at 0.25T magnetic field in STAR. The efficiency corrected $p_\perp^{tot}$ data spectrum is compared in Figure 1 to the Monte Carlo spectrum. The two spectra agree well, except in the lowest bin. The cross–section (normalized to total hadron cross–section) is presented in Figure 2. The cross–section was found to be 6.0mb $\pm$ 17% $\pm$ 19% which agrees well with the Monte Carlo prediction (7.8mb). In the experimentally accessible kinematical region with the present statistics we do not observe deviations from perturbative QED and the e^+e^-pair production appears to be independent of the nuclear excitation[3].

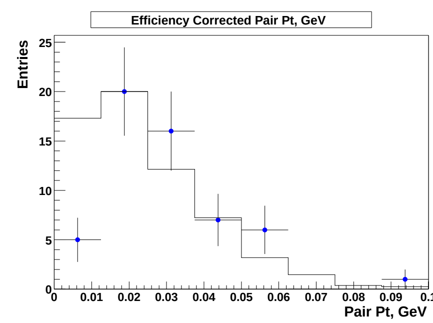

FIG. 1: Efficiency corrected total transverse momentum spectrum of the identified e^+e^-pairs (blue) and scaled Monte Carlo prediction (solid, black).

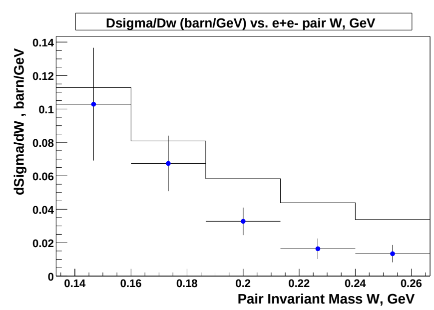

FIG. 2: Differential cross–section vs. pair invariant mass for the data (blue) and Monte Carlo prediction (solid, black).

[1] G.Baur *et al.*, Phys. Rep **364**, 359(2002).
[2] S.Klein and E.Scannapieco, Two–photon physics with STAR, STAR Note 243.
[3] V.Morozov, PhD Dissertation, UC Berkeley, 2003.